The Engineering News.

A Journal of Practical Science and Public Improvements.

PUBLISHED MONTHLY

AT 168 WASHINGTON STREET, CHICAGO, ILLINOIS.

GEO. H. FROST, Editor and Proprietor.

DECEMBER 15th, 1875.

TO OUR READERS.

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What we have accomplished in the former respect our table of contents will show; for the latter, our very respectable, and constantly growing subscription list is to us the best evidence of the appreciation of our efforts in behalf of first class special journalism. Indeed, the history of our paper has been to us a source of constant satisfaction, and if anything could indicate unmistakeably that we are supplying a genuine want in society, it is the steady progress that our journal has made and the enthusiastic reception it has everywhere met with, notwithstanding its own imperfections, and the continued financial depression that has existed all over the country since its first number was issued, and which still holds in its unrelenting grasp a great portion of the class whose support we seek. But from Maine to Oregon, and from Canada to Texas, with scarcely an omission, every state and territory, and every province, of the Union and Dominion, is represented on our subscription book. We have yet to receive the first letter of complaint, and we have not a single unpaid subscription on our list. Our constitnency is one of more than average intelligence, and instead of being dilatory as regards remittances, we have been the recipient of no small amount of commiseration, and conjecture as to how we could afford to give so much, for so very little apparent compensation.

We feel, therefore, personally interested in every subscriber, and we have endeavored, in all our correspondence with them, both private and published, to treat each one fairly and courteously, and to give all the information and instruction we possibly could. But we have been engaged, daily, a large part of the time in the field and office work of our regular practice as a surveyor, to say nothing of the days and weeks we have spent in trying to collect the pay for what we have done, and in consequence, some matters have been unavoidably neglected, for which we must be excused on the plea we have offered.

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The coming year is the nation's Centennial, and all the world is invited to celebrate it with us in a grand exhibition of the industrial products of all nations and all climes. Already the notes of preparation are ringing everywhere throughout the land, and we are glad to see that the popular enthusiasm in regard to the enterprise is increasing, and it is to be hoped that the reproach that has stigmatized the nation's share in previous similar exhibitions will be all wiped away in the record of the coming year. We do not expect to be able, and we shall not try, to give a complete description of everything on exhibition, or that transpires in Philadelphia during the coming season, as some of our contemporaries propose to do. We will only endeavor to describe and illustrate some particular department so well, that our readers will be abundantly satisfied with the results.

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ries respecting its aims, and the requirements for membership, from Engineers both in this country and Canada, and we feel certain that the society will soon show a largely increased membership and a corresponding influence, which in turn will affect the value of the papers read at the meetings and the discussion thereon. Excepting by members, these papers can only be obtained through our journal, and of themselves are well worth our subscription price.

We hope also to be able, as heretofore, to lay before our readers such papers as we may consider of general interest, from the transactions of the engineering societies in England and this country; we also intend to report as fully as possible the proceedings of the various scientific societies of this city, and of other cities where we can make arrangements to secure them.

We trust therefore that our present readers will appreciate the increased magnitude of our enterprise and that *every one* will sustain us by *promptly renewing* his subscription *this month*. Our journal will be increased in size of page to 10 by 14 inches; it will be eight pages at first, and will be printed on heavy, first class paper; great care will be taken to render its typographical appearance unexceptionable, illustrations of an inferior character will not be admitted, and we propose to issue a journal that will be in every respect creditable to the profession which it represents, to its publisher, and to this country of creditable newspapers.

We have placed the subscription at only $2.12 per annum, and to induce our friends to work for us we will send, for Ten Dollars—Five copies and the complete Volume of 1875; and we will send TEN COPIES for FIFTEEN DOLLARS.

Our present unassuming monthly is scarcely two full years old; it has not been advertised, nor has its merits been sounded by any solicitor; the place it now occupies has been won by force of its own merits, and yet its bona-fide circulation is rapidly approaching that of many of the oldest and most costly of the class journals of the Union, and the numerous club lists that have been sent us are sufficient to show that but little persuasion is required on the part of a solicitor to obtain subsciptions. The paper will recommend itself every time. We do not propose to remain content with the average circulation of class journals, and so we offer a large cash premium to those who will work for us. In these dull times Five Dollars are not easily earned, and we doubt if there are many ways more easy than taking subscriptions for as excellent a journal as ENGINEERING NEWS. We hope, therefore, to see a large number of "Clubs of Ten" coming in very soon. The present number is issued as soon after the Club Meeting as possible, and we will send to every subscriber the first number of the next volume as soon as printed, which will be about Christmas time.

Our Second Volume is now completed, and we send to each and all of our friends the compliments of the season, and hope that we may together see the return of many more.

Sixteen new drawing-room and sleeping coaches are being built by the Wagner Car Company for the Michigan Central railroad. Six hotel cars are also in process of construction, three of them being nearly completed.

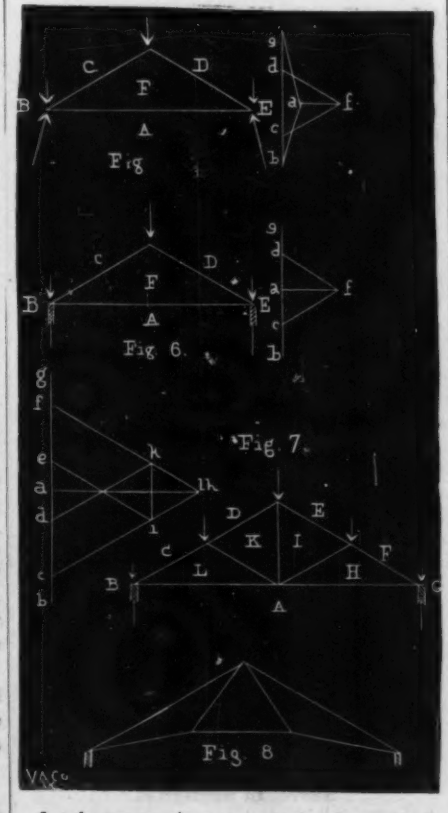
GRAPHICAL ANALYSIS OF ROOF TRUSSES.

BY CHAS. E. GREENE, A. M., PROF. OF CIVIL ENGINEERING, UNIVERSITY OF MICHIGAN.

II.

[Erratum.—Page 150, 1st column, 4 line from bottom, insert the italicised words in the following: "for the external forces, which must meet at one point (unless parallel), *in the frame diagram, make a triangle* in the stress diagram, &c.]

Suppose that the roof represented in Figure 5 has a certain load per foot over each rafter. Let the whole weight be denoted by W. It is evident that one half of the load on the rafter CF will be supported by the joint B and one half by the upper joint; the same will be true for the piece DF; therefore the joint at B will carry ¼W, the upper joint ½W, and the joint at E ¼W. The additional stress produced on CF by the bending action of the load which it carries is not considered at this time, but must be noticed and allowed for separately. Lay off *ed*, or ¼W to represent the weight ED acting downward at the joint E, next *dc* equal ½W, for the weight DC, and lastly *cb* for the weight at B. Call *eb* the *load line*.



Let the two reactions or supporting forces for the present be considered as a little inclined to the vertical, as shown by the arrows BA and AE. Since the truss is symmetrical and symmetrically loaded, the resultant of the load must pass through the apex of the roof, and, as the two supporting forces must meet this resultant at one point, the two reactions must be equally inclined. Then, to complete the polygon of external forces:—as we have drawn *ed*, *dc* and *cb* in order, passing over the frame to the left,—draw next *ba*, from the extremity *b* of the load line, parallel to the upward reaction BA, and lastly a line *ae*, parallel to the other reaction AE, to close on *e*, the point of beginning.

At the joint B we have equilibrium under the action of four forces, of which the two external ones are known. Therefore, taking them in the same order as in the case of the external forces, and commencing at *c*, pass over *cb* and *ba* in the direction of their actions; then draw *af* parallel to AF, denoting a pull on the joint B, and prolong it until *fc*, parallel to FC, will strike *c*, the point of beginning. FC will exert a thrust.

Passing next to the apex of the roof, we go down over the line *de* for the external force, thence up to *f*, and thence draw *fd*, parallel to FD. If this line does not close on *d*, the drawing has not been made with care. The stress *fd* will show thrust on the apex from the rafter FD. As all the stresses are now determined we need not consider the remaining joint.

If the supporting forces had been more inclined from the vertical, the point *a*, of their meeting in the stress diagram, would have been nearer *f*, thus diminishing the tension on AF. The inclination might be so much increased that *a* would fall on *f*, when the piece AF would become unnecessary, the thrust of the rafters being balanced without it. If *a* fell to the right of *f*, *af* would be a thrust. If the two reactions are vertical, as will be the case when the roof truss is simply placed upon the wall, BA and AE Fig. 6, will each be ½W, and the point *a* will be therefore found at the middle of *eb*. The polygon of external forces has closed up and become a straight line, but, in the analysis, it must still be used. Thus we have *ed*+*dc*+*cb* for the weights at the joints, and *ba*+*ae* for the reactions.

The explanation used when the stress diagram of Fig. 5 was constructed will apply equally well to this one.

The reader will find it very useful, when drawing a diagram for himself, to represent different kinds of stress by lines of different colors; thus lines denoting tension may be drawn with red and compression lines with black ink.

The same method of analysis will next be applied to the truss of Fig. 7. Here the rafters are supported at points midway between their extremities. Each point of junction of two or more pieces is considered a joint, around which the pieces would be free to turn were they not restrained by their connections with other points. Whatever stiffness the joint may possess from friction between its parts, or from a continuity of a piece, such as a rafter, through the joint, is not taken into account, and may add somewhat to the strength of the truss.

Mr. Unwin, in his excellent book on "Iron Bridges and Roofs," treats the rafter as a beam continuous over several supports, and determines the distribution of the load upon the several joints by this hypothesis. But, that such an analysis may be true, it is necessary that all the points at which the rafter is supported shall remain in a perfectly straight line. As this po-

[Entered According to Act of Congress, in the year 1875 by Charles E. Greene, in the office of the Librarian of Congress at Washington.

sition cannot be realized, a distribution of the load between any two joints of the rafter proportionally to its distance from each, in accordance with the principle of the lever, will best represent the case. A different distribution of the load, however, if one prefers it, will only require a corresponding division of the load line.

In the truss just taken up, therefore, half of the load on CL will be carried at the lower angle and be represented by the arrow BC; the other half, as well as half the load on DK will make the force CD, and so on, three of the joints carrying each one quarter of the whole load, and the two others one eighth each. On a vertical line lay off $gf = \frac{1}{4}W$, $fe = ed = dc = \frac{1}{4}W$, and $cb = \frac{1}{8}W$; then, $ba = ag = \frac{1}{2}W$, the two supporting forces. Now, for the joint B, cb=load, ba=supporting force; then draw *al* parallel to AL and *lc* parallel to LC; *al* is tension and *lc* compression. At the joint CD, the load is *dc*, the stress just determined on CL is *cl*: then draw *lk* parallel to LK, and *kd* parallel to KD, to close on *d*. There is compression on LK and compression on KD. Passing next to the joint DE, *ed* is the load, *dk* the thrust of DK on this joint, *ki* the tension on KI and *ie*, to close on *e*, is the compression on IE. Take next the joint in the middle of the lower tie; we have *ik*, then *kl*, and next *la*, the last of the known stresses. The next piece to which we come is AH; as we have just arrived at *a*, we must pass back horizontally until a line from *h* parallel to HI will close on *i*, the point from which we started. The remaining line *hf* is easily determined by taking either the joint EF or the one near G.

It will be noticed that, since the truss is symmetrically made and loaded, the stress diagram is symmetrical; *ki* must be bisected by *al*; *dk* and *ei* must intersect on *al*. Attention to such points ensures the accuracy of the drawing.

It is impracticable to determine the stresses at any joint where more than two forces are unknown. In the present case we could not start with the joint CD or with DE; for we should know only the external force or load and have three unknown stresses to find; therefore our quadrilateral, having one side known, might have the other sides of any length, while they were still parallel to the original pieces of the frame. By taking the joints in the order just observed this difficulty was not met with. When, in some cases, we find three or more apparently unknown forces at a joint, we may have some knowledge of the proportion which exists between one or more of them and a known force, and can thus determine the proper length of the line in the stress diagram. An example of such a case will be given soon.

We now submit a truss, Fig. 8, which the reader is advised to analyze for himself, as a test whether the principles thus far explained are clearly understood.

Correspondence.

W. D. C., City Engineer of Springfield, Ill., who is a very ingenious inventor, and, we should judge, a very careful surveyor, suggests that cement stakes be used for perpetuating section and other corners. Holes of proper calibre are to be made in the ground with a suitable tool, and liquid cement poured in; a nail could be inserted for a centre. We have no doubt this plan would work well where the surveyor was provided with the necessary facilities for the carriage of the materials and tools to be used, and where time was not an element of the contract; we do not think, however, that where a large number of corners were to be staked, the plan would recommend itself as suitable for adoption.

[Addenda to communication of July 31.]

The Government has the undisputed right to alter any lines prior to the sale of the adjoining lands, but it has no legal right to alter the boundaries of any lands subsequent to the sale. Hence, in case the overlapping was made after the sale of the opposite adjoining lands, the former method, as adopted by E. O., would in my opinion, be the legal method.

J. M., Co. Sur.

Intersection of Blazed Lines.

SHAWANO, WIS., Sept. 30, 1875.

EDITOR NEWS:—The results of my observations in regard to the intersection of distinct blazed lines at hundreds of both section and quarter section corners in the dense forests of this county, (Shawano) seem to corroborate your decision on page 106, Vol. II, in regard to the restoration of an extinct quarter corner upon a distinct blazed line, in preference to the straight line method, in cases where there is considerable discrepancy between the two lines.

It is noticed that the Court Decisions require that lost corners be restored in conformity to the best evidence which can be obtained, the pro-rata method being adopted as the last resort in cases of completely obliterated corners.

My experience has taught me that in a large majority of cases, the distinct blazed line method has proven to be the best evidence, as the pro-rata method often removes the section corner several rods distant from the point of intersection of distinct blazed lines.

Blazed lines between Government corners are found to be generally very crooked, especially in dense thickets, often running in a zigzag course varying from four to six rods from a straight line; but as a general rule, they intersect practically correct at points near Government corners, there being but few exceptions, hence I have adopted the following rule; that Government corners may be determined by the aid of distinct Government blazed lines in cases of entire absence of the original posts and Government bearing trees, or other evidence of the original position of the corner.

As a verification of the correctness of this method I will remark that I have often found the remains of the bearing trees subsequent to setting a temporary post for a section corner at the point of intersection of distinct blazed lines, only a slight correction of the temporary post being necessary to remove it to the original corner.

From the observations which I have made in this county the magnetic pole appears to be moving westward at the rate of about one degree in twenty-five or thirty years, making the variations about 5° which were recorded by the Government as being 6°.

Very respectfully,

J. M., Co. Surveyor.

"Survey of Section 6."

MR. EDITOR:—In the August number of the NEWS appears an editorial under the above caption, in which is given three or four methods of subdividing said section. It is not stated whether the figures are supposed cases or actually taken from official plats, but I infer the latter.

Now, Mr. Editor, these methods may be either right or wrong according to a few simple facts, easily determined: viz.—How did the Government divide and sell these lands? These subdivisions were authorized by the laws of 1820 and 1832 under regulations to be issued by the head of the Land Department. These regulations and instructions it seems, have not been entirely uniform, but have been amended and revised until we have the present manual of instruction of 1855, which is nearly the same as that of 1851. This portion of Minnesota was surveyed in 1853–4, and on the official plats the last half mile of every section on the north and west of every township, is divided into lots, the interior lots being invariably marked on the section lines 20 chains in width and marked and sold as containing 80 acres each. The width of the exterior lots are also marked on the section lines and the lots divided into quarter quarters and the number of acres as computed from the field notes, noted on each quarter quarter, and if sold separately are sold for the number of acres indicated on the plat, neither more nor less, and the U. S. patent describes it (as for instance the N. W. ¼ of the N. W. ¼ of Sec. 6, &c.,) precisely as interior quarter quarter sections are described, except the number of acres. All the surveys in this State so far as I know, and I believe also in Iowa and Wisconsin were made and the lands sold upon this principle and will come under the 1st case in Fig. 3 of your illustrations. The other subdivisions in Figs. 1 and 2 will depend on how Government divided and sold these lands. If Figs. 1 and 2 are fair representations, the official plats alone will not show how they were divided, but the plats, taken in connection with the patents issued for one or more of these subdivisions, will show how the subdivisions were made, whether an equal division or otherwise, and the surveys should be made in accordance.

I fully endorse "J. M." in every particular in his method of subdividing Sec. 6 given on page 122, in the September number of the NEWS, when applied to surveys made under the present or similar regulations of the Land Department. If, in earlier days a different practice prevailed in the survey and sale of the public lands, then in those districts, the surveyor should ascertain and conform to the instructions under which the survey and sale were made.

I have used for the last twenty years in my practice substantially the same rule and formula for determining the position of the quarter quarter corners both on the section and quarter section lines, as he gives in the solution referred to. I also endorse his position on the second and third questions referred to, for the reason that the language used is similar to that generally used in conveying Government subdivisions, and these subdivisions being the general rule, if an individual wishes to depart from it he must use such language as will unmistakably convey his intentions.

T, H.

MR. EDITOR;—Public surveys were made under contract according to the laws of the United States, and the instructions from the Surveyor General of the district in which the lands lay. Said instructions are generally printed and in pamphlet form. The following are extracts from one of these, issued in 1856.

Page 48.

"Last night (14th of April, 1845,) about 20.00 chains northwest of the corner to T's. 20 and 21 N., R's. 6 and 7 E., I ascertained the variation of the needle, by polar observation, to be 8° 35′ E.; I therefore adjust my compass at that variation, and to de-

termine the course of the east boundary of the township, commence at the corner of T's. 20 and 21 N., R's. 6 and 7 E., and run:—Thence N. on a blank line; at 40.04 chains fell 15 links west of the quarter section corner; at 79.96 chains fell 36 links west of the corner to sections 25 and 36, T. 21 N., R. 6 E; then from said corner to sections 25 and 36, run north (on the blank line) 39.97 chains, fell 18 links west of the quarter section corner; 80.05 chains, fell 37 links west of the corners to sections 24 and 25, *therefore, to run parallel to said east boundary of Township 21 N., R. 6 E., I adjust my compass to a variation of 8° 20′ E.*, which is *15′ less* than the *true variation*, and commence at the corner to sections 35 and 36, on the south boundary of the township and run—thence north, &c.

Page 28.

North and south section lines.—How to be surveyed.—Each north and south section line must be made one mile in measure by the chain, except those which close to the north boundary of the township, so that the excess or deficiency will be thrown in the northern range of quarter sections, viz.: [In running north between sections 1 and 2, at 40.00 chains establish the quarter section corner, and note the distance at which you intersect the north boundary of the township; and also the distance you fall east or west of the corresponding section corner for the township to the north; and, at said intersection, establish a corner for the sections between which you are surveying.

Page 29.

Surveying of East and West Section Lines.—The east and west section lines, except those in the west range of sections, and those which cross navigable water courses, will be run from the proper section corners, east, on random lines, (without blazing,) for the corresponding corners. Temporary posts will be set at 40.00 chains, and the distance at which you intersect the range or section line, and your falling north or south of the corner run for will be noted in your Field-Book; from which corner you will correct the line west by means of offsets from stakes, or some other marks set up or made on the random at convenient distances; remove the temporary post, and place and establish the quarter section corner on the true line, equidistant, or at the average distance between the proper section corners. If, however, you should strike the corner run for, you have only to blaze the line back, and establish the quarter section corner at the intermediate distance.

Page 30.

Surveying on east and west lines in the west range of sections.—The east and west lines in the west range of sections, will be run west on true lines; the quarter section corners will be established at 40.00 chains, the corners for the proper sections will be established at the intersection with the range line, and the distance which it intersects north or south of the corresponding section corner, west of the line, will be noted in the Field Book.

Page 26. (Appendix.)

What are called east and west lines, excepting those in the west tier of sections, are never due east and west at the variation assumed, unless a random line, which has to be first run, happens to strike the corner run for, &c.

Page 21. (Appendix.)

Former subdivisions of sections.—Previous to 1828 the Deputy Surveyors were required to return, with their field notes, plats of all the townships which they surveyed, and to calculate the area of the fractional sections on the navigable rivers and lakes, and in the north and west tier of quarter sections in a township.

These plats were rudely constructed, and, in many cases, the areas put down upon them were erroneous. When this fact was ascertained before the land was sold, a recalculation was made in the Surveyor General's office, and the Register of the Land Office in whose district the land lay, was furnished with a correct plat thereof, as a substitute for the one sent to him.

In making the calculations of the area of the north and west tiers of quarter sections in a township, some of the Deputies considered the quarter section corners on the township and range lines as common to the sections on both sides of the lines, whilst others adopted the method now in use.

At one time some of the Deputy Surveyors, in subdividing a township through which a navigable stream passed, ran a random line east, between the proper sections, and corrected it west, making the corner to the fractional sections on both banks of the river, and on the true line; others pursued the method as now required.

Page 22.

The areas in many quarter sections appear to have been put down without any calculation whatever, and it is therefore impossible to adopt any rule which will apply in all cases. The experienced Surveyor will generally be able to tell which of the foregoing methods was used in making the calculations of the area of a quarter section, and he should make subdivisions accordingly in retracing lines formerly run by Deputy Surveyors of the United States.

Page 33.

No rules can be given for the subdivision of fractional sections along the margin of a navigable lake, or the bank of a navigable river, for the reason that the subdivisions are made by the Surveyor General in such a manner as to give the fractional parts of the section the most convenient shape; and the surveyor must establish the lines representing the subdivision according to the official plat of the township by which the sales were made.

[Note.—Provided that the United States had not established a law regulating the mode of subdividing sections, or had I the power to adopt that axiom in Euclid which says "things that are equal to the same thing, are equal to each other," I certainly should run straight lines from the east or west quarter section corners to their opposites, and establish the centre quarter section corner at the mean distance, pro-rata.

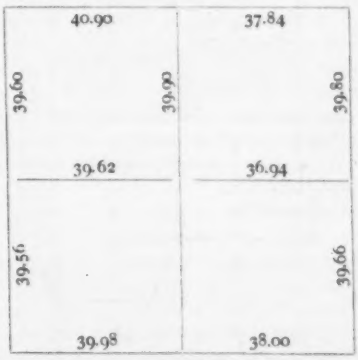
H. M., Portage, Wis.

Sec. 35, T. 23 N., R. 14 E. of 4th P. M.

NEW LONDON, WIS, Nov. 1, 1875.

EDITOR NEWS:—The effort J. V. B. is making for "equal areas" redounds more to the credit of his heart and his ideas of justice, than to his judgment or knowledge of the U. S. laws in regard to surveying. If he could understand that the equi-distant corners mentioned in the law, refer to corners set by the Government surveyors, instead of to corners to be set by county surveyors, perhaps his perplexity would be somewhat relieved.

Sec. 16, T. 21 N., R. 14 E. of 4th P. M.



The above diagrams are fair representations of said sections as the government left them. I have only added straight quarter lines. If J. V. B. knows how to divide one of these sections so as to make the northeast quarter equal to the northwest quarter, it will be in order for him to rise and explain.

B. F. D.

ONARGA, IROQUOIS CO., ILL., November 9th, 1875.

EDITOR NEWS:—I send you a plot of section 1 T. 25 N., R. 11 W. of 2d P. M., with the field notes marked along the lines. You will observe that the southeast and southwest quarters are each 160 acres; that the northeast and northwest quarters are divided into lots of 80 acres each, to the north lots along the township line, one of which has 142.29 acres, and the other 82.27 acres, the north line of the northwest quarter being 1.23 chains more than the south line of the southwest quarter, making a large excess in the west half of the section over that of the east half, and making nine lots instead of eight.

The question growing out of this case is, how shall the northwest quarter of the section be divided? shall the lines answering to 20 chain distances from the south side of the southeast quarter be extended across to the west line of the section, making each lot in the northwest quarter a little larger than the preceeding one, and cut off from lot nine the excess thus placed in them? In this way the lines will be run across the section from one corner to the opposite corresponding corner, and lot nine will lose several acres of valuable land, while the lots south of it gain that much.

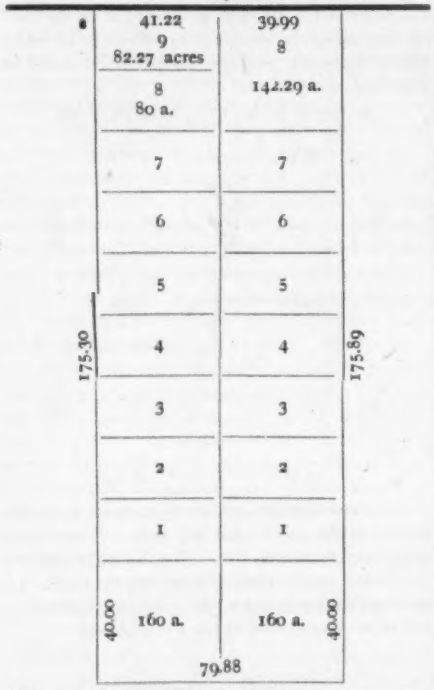
In sections of this form, of which there are many in this county, is it legal, under the laws of the United States governing the subdivision of sections, to make two sets of corners along the half section line, and a like set of double corners along the section line between sections 1 and 2. This must be the result if the area is taken into consideration in the division. The general opinion of the surveyors here is, divide the lines into 20 chain distances, or the proportional part, as excess or deficiency is found, and pay no at-

tention to the areas that may be called for in the patents. I would like to have the opinion of surveyors on the method of dividing this quarter.

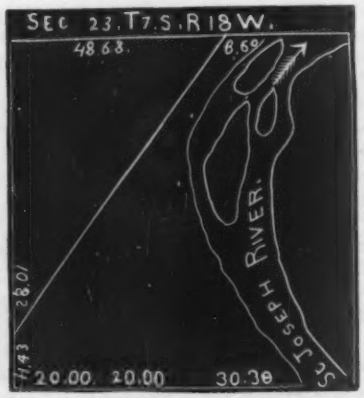
M. H. MESSER, Surveyor.

Sec. 1, T. 25 N., R. 11 W. of 2d P. M.

Township Line.



[ANS.—The calculations show that the area of lot 8 in the northeast quarter of the section is the product of the mean dimensions of that lot after allowing 20 chains for each of the other lots; the calculations for lot 9 in the northwest quarter by the same process shows that the area represented is incorrect and about 20 acres too much. Now the evidence goes to show that each lot was to have 20 chains width north and south, and the excess or deficiency was to fall in the last, or north lot: we should, therefore, assume that the lots were 20 chains wide, and divide the whole distance pro-rata on that basis, allowing the west front of lot 9 to have 15.30 chains, and make no jogs between the corners on the quarter line.—ED.]



The above is a diagram of section 23, T. 7 S., R. 8 W. of Meridian of Michigan.

It is desired to run the east and west quarter section line across the Indian Reserve in said section 23. The St. Joseph river, a meandered stream, runs across the section, making a fraction east of the river of 92.50 acres.

That part of the section lying east of the St. Joseph river was surveyed in 1828 by Wm. Brookfield, Deputy Surveyor. This survey includes the east portion of 92.50 acres.

That part of T. 7 S., R. 18 W., lying west of the Indian Reserve line was surveyed by Lucius Lyon, Deputy Surveyor, in 1827, and includes that part of section 23 west of the Indian Reserve line.

That part of T. 7 S., R. 18 W., lying east of the Indian Reserve line and west of the St. Joseph river was surveyed by Robert Clark, Jr., in 1835. This includes that part of said section 23 lying between the Indian Reserve line and the St Joseph river.

What work is necessary to be done to establish the line from A to B correctly? J. L., Co. Sur.

Berrian Co., Mich.

SOMERVILLE, MASS., Dec. 1, 1875.

DEAR SIR: The salary of the City Engineer of Somerville is $2,500, and not $2,000 as stated in your paper. Respectfully,

C. D. ELLIOT,
City Engineer.

Gas for Iron.

A revolution in manufacturing and an enormous development of our exports of iron are not unlikely to be the results of an experiment which has just been quietly and successfully tried in Pittshurg. The firms of Spang, Chalfant & Co. and Graff, Bennett & Co,, have brought the gas flowing from a well 15 miles from Pittsburg, through pipes to their furnaces, and have successfully substituted it for coal in the manufacture of iron. The cost of their experiment was $110,000, and each expects to save by this new fuel about $40,000 a year. The gas is almost pure hydrocarbon, and comes out of the ground with such power as to force it through 15 miles of pipe. The fuel furnished by the gas well is equal to about 100,000 bushels of coal a day. It gives a saving of more than 20 per cent in making iron, and is, beside, much cleaner, easier to handle, and more rapid in heating than coal. A puddling furnace that it takes several hours to heat by coal can be heated by this gas in three-quarters of an hour. A larger gas well is now flowing, three miles further from Pittsburg with such force that the stream of gas is thrown in flames 150 feet into the air. Its ownership is in litigation. When this is settled, and the capitalists, who stand waiting, are allowed to carry the gas to the city, the well will furnish, it is calculated, fuel enough to run all the manufactories in Pittsburgh. It is easy to see what results will follow from the general introduction of this cheap, self-feeding, powerful fuel, but it is impossible to measure them. The control of the iron manufacture of the world would seem to be inevitably ours with such an advantage. Other manufactures will seek the oil and gas belt country. If the supply of gas remains constant, the triangular district of which Pittsburgh is the apex and the Alleghenies are the base will become the greatest manufacturing district in the world.—*Chicago Tribune.*

Judge R. H. Duell of New York is commissioner of Patents vice J. M. Thacher resigned.

Astronomical Notes.—No. X.

PREPARED FOR THE ENGINEERING NEWS BY S. W. BURNHAM, F. R. A. S.

In a late number of the English Mechanic, Mr. Proctor speaks in flattering terms of the hospitality of the American people, and expresses some surprise at the larger audiences attending the lectures of his second visit, and the increased interest in astronomical subjects. In Boston, Providence, and Philadelphia a large number attended, the Evening Telegraph of the latter city making a full report of the lecture on the transit of Venus. The date of Mr. Proctor's appearance in the West has not been announced. He will be heartily welcomed by all who have already met him, as well as by the many who have been instructed and entertained by his books and writings on scientific subjects. Another volume of essays has just been issued by Smith, Elder & Co., entitled "Science Byways." It comprises fifteen papers, among which are: "Life, past and future, in other Worlds"; "The Planets put in Leverrier's Balance"; "Three orders of Comets"; "The Sun a Bubble"; "The Weather and the Sun"; "Danger from Lightning"; "The Growth and Decay of the Mind"; "Have we two Brains?"; "The Automaton Chess Player"; "Money for Science"; etc. It would be difficult to name Mr. Proctor's equal as a popular writer on astronomical and kindred topics. The apparently dryest subjects are by his pen rendered attractive to the general reader, and the present volume will be found to fully merit the popularity of the similar works which have preceded.

With a recent number of the Astronomische Nachrichten, Dr. Engelmann, formerly attached to the Observatory of Leipsic, issues a prospectus of an important astronomical publication, entitled "Abhandlungen von Friedrich Wilhelm Bessel" in which it is intended to reprint a selection of upwards of 130 of the more important papers of the great Konigsberg astronomer. The selection which has been made will be contained in three volumes, the first of which is to appear during the present month, the second in the spring, and the third during the summer of 1876, and will be arranged under the following divisions: (1) Motions of the Bodies of the Solar System; (2) Spherical

Astronomy; (3) Theories of Instruments; (4) Stellar Astronomy; (5) Mathematics; (6) Geodesy; (7) Physics, and (8) Various. A portrait and brief life of Bessel will be given. As many of these contributions are scattered in works costly and difficult to procure, this edition of the principal memoirs cannot fail to be of great service to the astronomical student.

A catalogue of 90 new double stars discovered by the writer during the past year is published in No. 2062 of the Astronomische Nachrichten. The observations were made with a six-inch refractor. Of the close pairs eleven are naked-eye stars, and the principal components of seven of the double stars of Struve, Herschel and South are again divided. Several of the pairs have been measured by Baron Dembowski, and his results are given. This is the sixth list in the series of discoveries with the same telescope, comprising altogether 390 new double stars, the larger part being close and very difficult objects with any ordinary aperture.

The asteroid hunters have been unusually fortunate of late. During the last month four new members of the system have been reported as discovered by two well known astronomers. Their places when first observed were as follows:

(151) Nov. 1	3h.	2m. ;	+18° 20′
(152) Nov. 2	2	38	+15 25
(153) Nov. 2	3	1	+17 35
(154) Nov. 6	2	20	+16 28

Palisa, of the observatory of Polo discovered (151) and (153); the other two were found by Henry at the observatory of Paris.

A new edition of Dr. Lardner's "Hand Book of Astronomy" revised and continued to 1875 by Edwin Dunkin of the Greenwich Observatory, is nearly ready for publication in London. Years ago this was considered a standard work, and its reappearance under the supervision of so able a writer and astronomer will be a valuable addition to astronomical literature.

The Baltimore and Ohio Railroad Company has completed arrangements with a new foreign line of steamers to ply between Baltimore and Liverpool, the first vessel of which will leave Glasgow in a few days. Each ship is to be of 2,300 tons capacity and built expressly for carrying heavy cargoes of grain. The regular trips will be begun in the latter part of December.

Mathematical Column.

PROBLEMS.

18. What must be the length of a rigid cord fastened at one end to the outside of a circular wall ten feet high and one hundred feet in diameter, that will allow a generating point fastened at the other end, to trace a curve inclosing with said wall one acre of ground; and what would be the length of the entire boundary line. J. M., Mansfield, O.

19. What is the length of the longest inflexible pole that can be put up a chimney, height of the mantle, b and width, a. Id.

20. Let a cubical vessel whose sides are each nine square feet, have a tube one inch in diameter and nine feet long inserted in its top, and let them be filled with water; required the weight of water therein contained, and also the amount of pressure created.

H. M., Portage, Wis.

SOLUTIONS.

10. page 108. If we conceive a line drawn from the zenith to the star, from the star to the North Pole, from the North Pole to the zenith; we have the spherical triangle of one problem. We will represent the lines in the order named by a, b, c, the angles opposite by A, B, C, the right ascension by R, latitude by l, longitude by L, and sidereal time by T.

In astronomy, A is called the hour angle, b, the polar distance and c, the co-latitude. For the solution of our problem we have the equation

sin. A cot. B—sin. c cot b—cos. c cos. A (1)

which may be found in any standard work on Trigonometry. Take h sin. P—cos. A (2) h cos. P—cot. b (3), substitute (2) and (3) in (1) and

sin. A cot. B—h(sin. c cos P—cos. c sin. P), or

sin. A cot. B—h sin. (c—P), elimininate h, by means of (2) and $\cot. B = \frac{\sin.(C-P)\cos. A}{\sin. P \sin. A}$ (4.) Divide (2) by (3) and ton. $P = \frac{\cos. A}{\cot. b}$ (5.) Equation (4) and (5), solves the problem when the time is given. Take k sin.P—cot. B (5), k cos. P—cos. c (7), substitute (6) and (7) in (1) and we have

k(cos. A cos. P+sin. a sin. P)—sin. c cot. b; or,

$\cos.(A-P) = \frac{\sin. c \cot. b}{k}$ Take A—P—Q then, A—Q+P, eliminating k by means of (6) and we have

$\cos.Q = \frac{\sin. c \cot. b \sin. P}{\cot.C}$ (8), Divide (6) by (7) and $\tan. P = \frac{\cot. B}{\cos. c}$ 9 Equation (8) and (9) solves the problem when the azimuth is given.

The process is very simple when the sun is observed, but being a little abstruse when a star is observed, we illustrate by an example. The azimuth of Arcturus, observed at Mansfield Oct. 1st. 1875, was N.78° 20, W.; what was the local mean time?

Latitude 40° 44′ N., Longitude 5 hours 30 minutes west from Greenwich. For this date we find by the English Nautical Almanac R=14 hours, 9 minutes, 58.48 seconds, b=70° 10′ 6″ c=90°—b=49° 16

By (9)

B=78° 20′	Log. cot.	9. 3148851
C=70 16	Log. cos.	9. 5570818
P=17 33 32	Log. ton.	9. 5002784

By (8)

c=49° 16′ 0″	Log. sin.	9. 8795287
b=70 10 6	Log. cot.	9. 5590818
P=17 33 32	Log. sin.	9. 4795539
B=78 20	ar. co. Log. cot.	0. 6851146
Q=66 28 10	Log. cos.	9. 6012793

But, A—Q+P 84° 1′ 32″, in time 5hours, 36minutes, 9.10 seconds, add this to the right ascension R, and we have the local sidereal time,

A+R—T—19hr.46 min. 5.58 sec.

Eng. N. Alm. p. 2 of month V—12 39 14.88

T—V —	7	6	50.70
cor. for T—V	—	1	10.11
cor. for L	—		54.20
Mean astronomical time	7h.	4m.	46.39 sec.

This method of obtaining time is inferior to that of an altitude with the Sextant.

JOHN NEWMAN,
MANSFIELD, O.

10, page 108. Let φ—latitude; δ—declination of sun or star; t—hour angle; A—Azimuth; ζ—zenith distance.

(1st.)
$$\tan M = \tan. \zeta \cos. A$$
$$\tan. t = \frac{\tan. A \sin. M}{\cos. (\varphi - M)}$$
$$\tan. \delta = \tan. (\varphi - M) \cos. t$$

(2nd.)
$$\tan. M = \frac{\tan. \delta}{\cos. t}$$
$$\tan. A = \frac{\tan. t \cos. M}{\sin. (\varphi - M)}$$
$$\tan. \zeta = \frac{\tan. (\varphi - M)}{\cos. A}$$

13, page 134. Let W—large weight; a the inclination of the plane, and V the velocity of either body when the string breaks: then $v^2 = 2\rho' s$; but

$$\rho' = \frac{\text{moving force}}{\text{mass}} = \frac{W - \frac{1}{2}W \sin. a\ \rho}{W + \frac{1}{2}W}$$

$= \frac{1}{2}(2 - \sin. a)\rho$: hence, $v^2 = \frac{2}{2}(2 - \sin. a)\rho s$ is the velocity with which the small body begins its ascent alone; and it will rise to the height

$$s = \frac{v^2}{2\rho'} = \frac{v^2}{2\rho \sin. a} = \frac{\frac{2}{2}(2 - \sin. a)\rho s}{2\rho \sin. a}$$

From this we have $2\rho s \sin. a = \frac{2}{2}(2 - \sin. a)\rho s$

$3 \sin. a = 2 - \sin. a$ $\sin. a = \frac{1}{2}$ and $a = 30°$

L. S., New Haven, Ct.

The second special report on the geology of the oil regions is now issued by the Pennsylvania State Geological Survey, consisting of Mr. Carll's survey of the outcropping rock, from New York State through Pennsylvania to Ohio. A very noticeable feature in this report is the discrepancy discovered between the surveys of New York and Ohio geologists and those of Pennsylvania. The reports of Ohio and New York had been already published, and it was expected that the survey through Pennsylvania would show the oil strata of the three states to be parts of one continuous belt. It does not so prove, however, and it now seems as if somebody had made a mistake, or else some finely elaborated theories in regard to the oil formation must be abandoned.

Law and Legislation.

An abstract of decisions of the Supreme Court of the United States and of the courts of the various States in the Union upon questions relating to boundaries, surveys, etc. Compiled for the ENGINEERING NEWS by John Dunn. Esq., Attorney at Law.

337. Where the map accompanying a grant is incorrect in its lines of latitude, the grant may be located by reference to natural objects. United States v. Sutler, 21 Howard (U. S.) 170.

338. In ascertaining the boundaries of surveys and patents, the universal rule is this :—that whenever natural or permanent objects are embraced in the calls of either, these have absolute control, and both course and distance must yield to them. Brown v. Huger, 21 Howard (U. S.) 305.

339. Thus where a survey and patent call for a boundary to run down a river to its junction with another, thence up that other to a certain point, the rivers must be taken to be the boundaries, and the courses must be disregarded, especially if one of the courses has been manifestly interpolated through error. [Ibid.]

340. The line between adjoining owners of land may be established by them by parol agreement, and such agreement when executed is conclusive upon the parties and all claiming under them. Orr v. Hadley, 36 N. H., 575.

341. A description of land calling for "a piont in Laurel Swamp" as the beginning, and giving course and distance for all the rest of the description, is so vague that no land can be located under it. Archibald v. Davis. 5 Jones Law (N. C.) 322.

342. In locating a patent of ancient date, evidence in respect to marked trees, though not called for on the Grant, is admissible. Topping v. Sadler. 5 Jones Law (N. C.) 357.

343. In ascertaining the lost corner or boundary of a section, which must be presumed, in the absence of evidence to the contrary, to have been established and marked in the original survey, recourse must be had to the unobliterated marks and corners of that survey ; the field notes and plat, and subsequent surveys made under their guidance, although such subsequent surveys are not proved to correspond, in every particular, with the original survey. If only a portion of one of the boundary lines leading to the lost corner has been obliterated, the remaining portion, whether straight or not as marked, must be considered as established ; and the corner must be presumed, in the absence of evidence to the contrary, to be at the point where the marked line, if continued, would intersect the township line. But if the lost corner is proved to have been at another point, the lost portion of the boundary must be ascertained by running a straight line from the point at which the marks disappear to that corner. Billingsley v. Bates 30 Ala. 378.

344. The corners and boundaries of sections, as marked and run by the United States surveyors in their original surveys, although not located with mathematical precision, are established by law as the proper corners and boundaries, and cannot be altered or controlled by other surveys. [Ibid.]

345. In an action of boundary, where the titles of both parties are derived from the same original vendor, the calls of the titles of the parties as understood at the time they were made, and according to the usage of the country at that time, cannot be disregarded on account of more recent surveys made by the government, which would change their boundaries. Lawrence v. Burris. 13 La. Ann. 611.

346. Where adjoining proprietors, being unable to ascertain the division line, agree verbally upon a certain line, the agreement is binding, and improvements by one up to the line is notice thereof to a purchaser from the other. Houston v. Sneed, 15 Texas, 307.

347. The acquiescence of the proprietors of the adjoining lands in a particular line is not unfrequently referred to and received as evidence to determine their boundaries. Prior possession is notice of the claim of the person in possession to the purchaser of adjoining lands. Bolton v. Lann, 16 Texas, 96.

148. A division line, mistakenly located and agreed on by adjoining proprietors will not be held binding and conclusive on them, if no injustice would be done by disregarding it. Menkens v. Blumenthal, 27 Miss. 198.

349. The corners established by the original surveyors of public lands under the authority of the United States are conclusive as to the boundaries of sections and divisions thereof, and no error in placing them can be corrected by any survey made by individuals or by a State surveyor. Arnier v. Wallace, 28 Miss. 556.

350. A boundary may be rejected, when it is clear that it was inadvertently inserted, and that a tract with different boundaries was intended to be conveyed. Gibson v. Bogy, 28 Miss. 478.

The **ANALYST,** a Journal of pure and applied mathematics, published bi-monthly, at Des Moines, Iowa, for $2.00 per year, or 35 cents per single number.

J. P. HENDRICKS, A. M.,
Editor and Proprietor.

A large building for the manufacture of malleable glass by the La Bastie process has been commenced in France, at a cost of $625,000. The building is 163 yards by 160 yards in depth.

Business Training.

These are days of failure, of disappointments, of discouragements. Men have speculated too much, spent too much, plundered too much, inflated too much; and perhaps have been told of it all too much, as lessons with morals attached are doled out every day in the week from editorial columns. It will not come amiss in the midst of this plethora of evils to suggest something which the country has had too little of—and that is, proper business training for business men.

A well conducted business has a two fold aspect; its internal systems and methods comprising the general machinery of its automatic action; and its external connections, through which it asserts itself as a power. To know it internally, it is necessary to watch each day's work as it is carried, clearly and accurately, from folio to folio, with every scrap of information or voucher carefully collected and preserved; and to understand how the daily work is related to profit and loss. To know it externally, it is necessary to study the moves of the head of the house, as he links his operations with those of others, and makes his machine work harmoniously with the whole trading system.

It is plain to see from this what kind of training is essential. To acquire a thorough knowledge of all details, and to learn to give to them close, methodical, patient attention, is the primary step. The head of the house needs it fully as much as the clerks in his employ, for only thus does he become master of the situation. Every business must be economiclly administered, both as to the expenditure of money and of muscle ; and the head that guides it ought to know how each hour's work of every subaltern is effective to the end in view.

Business in this country can never be placed on a firm, safe basis, until those who conduct it realize that it is a calling which requires trained skill as well as the trades and professions.

Minutes of the December Meeting of the Civil Engineers' Club of the Northwest.

The 61st regular meeting of this Club was held at the Sherman House Club Rooms, on Tuesday, December 7th, 1875, beginning at 4:30 P. M.

The minutes of the November Meeting were read and approved.

Mr. W. S. McHarg, an associate member, was elected a member of the club,

Mr. E. B. Noyes was proposed for membership by Messrs. G. H. Frost and B. Williams.

The paper for the evening, No. 56, "THE ALBANY WATER WORKS," by Mr. I. C. Chesbrough, was read by Mr. E. S. Chesbrough.

Discussion of the paper, and topics relating to it, occupied so much time that other business was postponed.

The meeting adjourned.

L. P. MOREHOUSE, Sec'y.

CIVIL ENGINEERS' CLUB OF THE NORTHWEST.

No. 56.—THE ALBANY NEW WATER SUPPLY.

A Paper read before the Civil Engineers' Club of the Northwest, December 7, 1875, by I. C. CHESBROUGH, C. E.

Albany, the New York State Capital, is by natural position a place of much importance. It is also becoming an extensive manufacturing centre. To maintain its prosperity an abundant supply of good water is essential. The supply must not only be abundant for present but future wants. Something more than impounding the waters of small streams or limited drainage areas is required.

Much time and professional labor have been spent in devising schemes for the water supply of the city of Albany. Examinations were commenced in 1841 by Civil Engineer Cushman, followed in 1846 by Major Douglass, and finally by Mr. W. J. McAlpine in 1850. A private company had been supplying the lower part of the city. Their works were purchased and continued in use by the city. Every available source was examined, and the various reports submitted will show how much study was given to the question. A supply by gravitation was decided upon, the source being the Patroon creek, with a gathering pond about 5½ miles west of the Hudson river. The surface of the reservoir is 258½ feet above extreme low water in the river, and the supply is conveyed by a brick conduit (3′ × 4′ oval) a distance of about four miles, by its course, with a fall of one foot per mile to a distributing reservoir in the northwestern part of the city, two miles from the river.

At another locality of 100 feet lower elevation on Patroon creek, a reservoir, the Tivoli, has been constructed for supplying the lower part of the city. Fortunately there has been until the present exceptional season a surplus at the Tivoli reservoir, so that for several years a deficiency in the upper one has been supplied to it from the lower one by means of a Worthington pump. The city has thus been enabled to keep up its needed supply, but the greatly increasing demand for water, and the decreased supply as compared with the original estimates, has made manifest the absolute necessity of a more abundant and unfailing source. It may be well to remark here that from two to three times the quantity estimated as sufficient 25 years ago, is now used, or wasted, in our large cities.

After a careful consideration of the question by the Water Commissioners, they decided to recommend the plan suggested about 25 years ago by Mr. Carpenter, then City Engineer and now Superintendent of the water works, namely, to take the water from the Hudson river opposite the foot of Quackenbush street, carry it through the Pier and under the canal basin to a pumping well west of the basin, and thence by machinery force it to a reservoir on the high ground in the northwest part of the city.

Mr. James P. Kirkwood was engaged to investigate the plan and make an estimate of its cost. The estimate was made and the Commissioners were authorized to proceed with the work. The writer was appointed to take charge of its construction as Resident Engineer, Mr. Kirkwood being retained as Consulting Engineer.

The plan estimated for, consisted of an outlet at the east face of the pier; a culvert leading to a gate chamber in the pier; a 36″ pipe passing under the canal basin and under the railway tracks to a receiving well near the corner of Quackenbush and Montgomery streets, 900 feet from the river, at which point the pumping engine was to be located, and from which a force main 30″ in diameter 1¾ miles long, was to lead, via Clinton avenue, to the distributing reservoir already constructed, and known as the Bleecker reservoir. On a careful examination of the plans by the Resident Engineer he did not see anything to suggest in the way of changing the general plan as worked out by Mr. Kirkwood, except for the mode of supply to the engine. To that the objections were, the difficulty of laying such heavy pipes in the deep trenches (one part over 30′) needed under the numerous tracks of the New York Central and Delaware & Hudson railways, and the probable interference with navigation in the canal basin, with the consequent uncertainties of the cost of the work. A Tunnel was suggested and adopted.

DESCRIPTION OF PLAN BETWEEN THE RIVER AND THE PUMP WELL.

A port wall of stone work with port protected by a grating to prevent ingress of large floating substances; a chamber in the wall with gate to regulate the flow of water to a culvert leading to a shaft in the middle of the pier between the river and canal basin; in the shaft a copper wire screen; shaft ten feet cylinder of brick; from the shaft a tunnel 5 feet diameter leading to a pump well at the engine house. [A double engine with beams and single cylinders connected with one fly wheel to force 10,000,000 gallons in 24 hours to the distributing reservoir through a 30″ pipe 1¾ miles in length, 250 feet high, has been erected and the force main laid.]

PRELIMINARY EXAMINATIONS.

Examinations of the ground for the tunnel were first made by boring The tool used was an augur similar to that described by Mr. E. C. Clark in his paper of March 9, 1874. The material at the proper depth proving to be hard pan with boulders, it was exceedingly difficult to reach any considerable depth by boring. When not striking large stones a penetration of a few feet could be obtained by a churning process, using water to soften the material. In order to obtain a perfectly satisfactory examination, in one place at least, a well was dug to the required depth. It is doubtful if any means, much less expensive than the construction of the tunnel itself would have developed the treacherous spots which are so much dreaded by the experienced contractor. The later examinations made developed bad ground not indicated by the first trials. Had the exact nature of the ground under the pier and east side of the basin been anticipated, it is probable the plan of a tunnel under the basin would have been abandoned. The city has now, however, a tunnel with a delivering capacity about four times as great as a 36″ pipe, which will be of great importance when an increased supply is needed. The increased capacity was an argument in favor of the tunnel plan, even at an increased cost, though it is not certain a 36″ pipe could have been laid any cheaper.

CONSTRUCTION OF THE TUNNEL.

The first contractor took the work at a very low price, without a personal examination of the ground. He soon abandoned it by consent of the commissioners and it was relet to the next bidder. D. D. McBean, of Chicago, whose price was double the first, and considered ample for all contingencies, as he was known as an expert. He commenced operations first for the land end, *i.e.* west of the canal basin, on the 24th January, 1874, and completed 644 feet, extending 100 feet under the basin, on the last day of March following. It was done by means of two shafts and a short drift from the well pit at the engine house. Thus far it was quite successful and remunerative. The price was $31 per lineal foot, and one shaft retained permanently was paid for. The other shaft was entirely closed The drifting was done in the usual manner with two miners at each face, and working eight hours each shift. The only cessation of work was from 7 a. m. to 11 p. m. on Sundays, one face being kept as a reserve while the bricklayers were at work. The grade of the tunnel from the engine house to the canal basin was 1′ in 30′. Care was taken to avoid undulations in the grade and to have the ends meet properly. The shore end of the tunnel, as above mentioned, was carried under the canal basin on the grade of 1′ in 30′, and for a distance of 75 feet in as good ground as was found in the whole distance, in fact dryer than most of it. Unfortunately the ground there was found "demoralized," and at 100 feet so much water came in through the now sandy material, that operations were suspended and it was decided to complete the tunnel from the pier shaft, where the grade was supposed to be much more favorable.

PIER SHAFT.

The pier shaft was commenced on the 10th of February, 1874, and was sunk in the middle of the pier. It was commenced 10′ in diameter with brick walls, and started on a shoe, and not expected to go much below 40′. The pier is a clay filling, 78′ wide and about 16′ deep, resting on a sandy and gravelly bed of about 11′. This rested on a hard stratum 17′ below extreme low water mark, There is a tide of two feet ordinarily. The depth of 27′ was not reached until the last day of March. An influx of water commenced near the bottom of the clay filling. At first it was removed by a small pump but soon a 3″ centrifugal was used, then a No. 9 "Pulsometer," then both centrifugal and Pulsometer, and finally before reaching the bottom of the curb, both were inadequate with the power at command.

Before reaching the depth of 27 feet, much difficulty was encountered in lowering the curb and keeping it near a proper position, leaning as it would at different times, toward all points of the compass, righting it, or holding

it as the case might be, by excavating under one side, propping another, by weighting, by using a heavy beam lever inserted in the outer side of the wall, and by excavating outside to remove external pressure—where within about 3 feet of the bottom of the sand the curb stuck, though weighted with 60 tons of pig iron and more than a foot excavated below the shoe. It became evident there was something more than friction to prevent gravitation, as was afterwards discovered in finding it fouled, principally by small boulders. The contractors then decided to let the shaft fill with water and reach the hard stratum by means of divers. On the 20th the divers were at work. Found some stones under and behind the shoe and managed to excavate about 3 cub. yards of earth and boulders per day in about 20 feet of water (the river being high). This continued for 2 or 3 days by which time it was difficult to proceed further in that way. On the 24th a city fire engine was obtained, and by forcing a powerful jet, in less than two hours the curb was lowered 13 inches. Progress was 2 inches on the 16th, 4 inches on the 23d., on the 25th the divers were busy shoveling sand that had come down from behind the curb. On the 31st, after applying the jet again and lowering the curb about 20 inches the hard stratum was reached.

April 1st. pumped out water, but on account of bad ground the shaft was allowed to fill again. In the afternoon the divers resumed work, excvating coarse material, some stones, probably from an ancient bed of the river.

7th. Tried jet again and lowered curb 17 inches.

8th. Curb settling all day and reached 4 feet below sand bed, and what was originally considered depth to hard pan.

Depth now reached 15 feet below datum, the shoe resting on material, principally sand and gravel. but soon becoming by disturbance, like quicksand; it was not a safe material to start a drift in.

The influx of water made it necessary to work with divers from March 20th to April 9th; expensive operation. On the 10th the shoe had reached 17½ feet below datum, in apparently good ground, but April 11th. an irruption occurred filling 15 feet of the shaft with sand and gravel in a few minutes. The effect of this was to cause a considerable subsidence on the surface outside of the shaft. The pump apparatus was in working order again before night. The shoe was cleared out by the 13th, and settled 4½ feet, or to 23 feet below datum, about the depth originally intended. The curb was bricked up on the night of the 14th, to 40 feet above the shoe. On the 15th the curb was loaded again with iron. On the 16th the water was pumped out and excavating resumed. The soil might now be called a well packed blue quicksand; on the 17th after getting down 3½ feet farther, another irruption occurred, more than half filling the shaft and forming a big crater around it. This irruption was sand, gravel, and many stones, also shells, bits of crockery, brick-bats, &c. from the bed of the river, and a considerable quantity of vegetable matter. Pumping apparatus again caught, but was relieved by hoisting out earth in buckets. The influx of water, except by these sudden irruptions, could now be kept down without a pump. The shaft cleaned out to within 4 feet of the bottom of the shoe; when boring rods struck almost impenetrable ground, 6 feet below the shoe. It was decided to keep on lowering the curb, when on the 21st another irruption occurred, equal to the last in quantity, but did not fill so rapidly. The subsidence at surface was now so great as to disturb the Pier nearly its entire width, and cracked the walls of the curb badly—north and south sides, and lower part principally, and one side of the crack was pushed in a little. It is seldom that curbs are sunk to such a depth without underpinning, and in this case no rods had been placed for the last 10 feet, and the batter of 4 inches on the outside face had now run out, making it necessary to continue with perpendicular sides. It was now decided to be unsafe to continue sinking the present curb, and a 7½ foot one was started inside with shoe and rods. Bottom of 10 feet curb now 29¾ feet below datum, nearly 47 feet below surface of Pier. Nothing more was done till May 1st when the outer curb was bricked up to above surface of Pier, and then we commenced taking out sand now 25 feet deep. A considerable amount of vegetable matter came to the top with the last irruption. May 2d. Cleaned out deep enough to lower shoe for 7½ feet curb, and let fill for over Sunday. On the 7th had built the first section of the lower curb (16 feet), on the 7th reached a bed of boulders. The lower curb was forced down by means of powerful jacks against timbers set in the walls of the 10 feet curb, which was separated half round by the operation. They nearly closed again after the jacks were removed and no further start took place in the vertical cracks of the outer curb, nor did any water come in through these cracks. On the 8th both curbs settled about 11 inches. On the 11th were at work in a bed of small boulders. At 37 feet below datum a few inches of hard pan crust and then into some loose sand and gravel. The outer crust had settled 15 inches since April 21st or 2 or 3 inches since May 8th, and slowly moving; 8 jacks at work requiring heavy oak timbers to bear the strain. The bed of boulders, about 2 feet deep, was passed through and about 4 feet of indurated material below its when another stratum of sandy material was struck. The hard pan crust was too much broken to venture out under it, with over 50 feet head of water to contend against; on the 14th there was a slight run filling 2 or 3 feet. After forcing the curb about 3 feet below the hard pan, the 5th irruption occurred. Another section (8 feet) was built on the top of inner curb. The last irruption tried the brick work of the lower curb, bulging it on S. W. side, and letting water come through in showers upon the workmen.

The material now reached was compact sand and boulders. May 18th, another slight irruption, after which the water for some time ceased spouting. The shaft was cleaned out and a careful examination made. Some bricks near the bottom had been shoved in. Another, and the last irruption occurred on the 10th. The shoe had now reached very near the bed rock. The force of the water this time drove out the packing from between the curbs, and flowed violently over the top of the lower one, causing considerable alarm among the men, and filling about 8½ feet of the shaft. On a careful examination of the situation it was decided unsafe to attempt any further disturbance of the brick work.

Examination by drilling into the rock 12 feet showed that the black slate which is known to be of immense depth had been reached. Four cast iron cylinders 5 feet long and 6 feet in diameter were then ordered for further progress, and to secure the work already done. Commenced lowering them June 17th. The rock proved so sound that the lower cylinder was only set a few inches into it. The surface of the rock was 45 feet below datum. The 4th section was put in place June 20th. There was so much discomfort however to the men in the over dripping water, that another section, 6½ feet, (of lighter material) was ordered. This carried the cylinder above the top of the lower brick curb, and formed a well behind it from which the water was pumped. There was just room to set this cylinder vertical in the 7½ feet curb, as the upper curb had taken a slant and the lower one had to be carried in the same direction, there being but three inches space between.

On the first of July, having secured a tight joint for bottom of cylinder the work of sinking into the rock commenced. The shaft was carried 15 feet into the rock. On the 16th a drift of 6 feet diameter was started with top 6 feet below surface of rock, with regular mining gangs. The progress at first was only 2 feet in 24 hours, by the use of ordinary black powder. This rate was continued for 75 feet, when another explosive called "Rend Rock" was used. This was very powerful. At first the men complained much of headache from the use of it: it was continued, however, and the rate of progress was increased, first to 3 feet for about 75 feet, and then to 4 feet per day, at one time reaching 4½ feet for a short distance.

A hole was blown through the connecting shaft on the morning of November 12th, and on the 18th the tunnel was accepted as sufficiently completed. It was not considered necessary to line the rock drift, the rock being sufficiently sound, and the stratification favorable for permanence.

The drift was started and continued with slight inclination for about 150 feet, when the inclination was increased. Before going too near the proposed point of connection with the shore end, that part was pumped out and a connecting shaft was commenced (35 feet back of the end to insure starting in good ground) to ascertain the character of the material below. The rock was struck at a depth of less than 4 feet. It was then decided to sink a shaft of only sufficient depth to run into and have 4 feet cover of rock. This was done by starting 220 feet from the pier shaft and rising 1 in 2½. The connecting shaft and end of drift was lined with brick. The alignment came out right.

The work of the port wall and culvert was done during the construction of the rock drift, and in a very simple manner. A trench was excavated to the water, the pier wall was cut through, and then the trench dredged deep enough for driving piles. These were sawed off under water and the masonry laid in a caisson. A short piece was left to join at the shaft. This was accomplished by making a clay dam, and, after pumping down the water, making a connection by cutting through the end of the caisson and into the outside of the curb. The connection being made and all closed over, an opening was cut through the curb wall. The screen was placed, shaft covered over, and the work was completed.

Had it not been for the experience of both contractor and engineer in a somewhat similar operation under the Detroit river, they would have been at times much discouraged with regard to the accomplishment of the work without greatly exceeding a justifiable expenditure of means.

A longitudinal section accompanies this paper.